XIX. *Results of the Magnetic Observations at the Kew Observatory.*—No. III.

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§ 9. *Lunar-diurnal Variation of the three Magnetic Elements.*

THE recognition of a cosmical origin of some of the variations of terrestrial magnetism has made it desirable to employ in magnetic observatories apparatus of a more exact and dependable character, and methods of dealing with the results thus obtained of a more close and rigorous description, than were previously thought requisite. The present communication is directed to the discussion of the Lunar-diurnal Variation of the three magnetic elements shown by the instruments and methods adopted at the Kew Observatory, commencing in 1858, and continued as far as the reductions have at present proceeded, viz. to the close of 1864. It has the double purpose, first, of making known the systematic and highly satisfactory character of the results which have been already obtained; and, second, of acting in some measure as a guide, and certainly as an encouragement, to the several establishments at home and abroad which have adopted the Kew System of magnetic investigation.

The instruments employed for the determination of the lunar-diurnal variation furnish a continuous photographic registry of the changes in the direction of a magnet whose motion is limited to a horizontal plane, and in the amounts of the horizontal and vertical components of the force acting on a freely suspended magnet. The photograms which record these changes are submitted to a very careful and exact process, by which the variations from a permanent zero, of the horizontal magnetic direction, and of the amounts of the horizontal and vertical components of the Force, are measured and tabulated at twenty-four equidistant intervals of an astronomical solar day. The accuracy of the tabulations is checked by a repetition of the process of measurement by different persons, and by a reexamination in cases of discrepancy. The proportion of failures in the hourly records from any or from all causes whatsoever is very small—less in fact than 1 per cent. throughout the whole period. The subjoined Table (No. I.) shows that of 175344 positions which should have been recorded, there were only 1497 failures, of which 103 were occasioned by the employment of the instruments in other experimental processes. It must be remembered also that the period under notice is that of the *commencement* of the record, when experience has to be gained, and the causes of accidental failures have to be remedied.

The positions thus measured from the photograms at every hour of astronomical time, and entered in monthly tables, were then subjected to the usual processes, first,

of computing the monthly means for each of the twenty-four hours in every month; and second, of marking (for subsequent exclusion) every hourly position which differed from the mean of the same hour in the same month, not less than a certain specified and definite amount; such difference being regarded as evidence of the presence of a magnetic disturbance. The amount of difference thus adopted as a criterion (known commonly by the name of "the separating value") was constant throughout; being 0·150 of a scale-division in the Declination, and 0·106 of a scale-division in each of the other elements; equivalent to 3′·3 of arc in the Declination, ·00109 part of the horizontal force at Kew, and ·000269 part of the vertical force at Kew. The number of hourly positions thus separated was, in the Declination 10271, or about 1 in 5·9 of the whole body; in the horizontal force 11·747, or about 1 in 5·1 of the whole; and in the vertical force 13·562, or about 1 in 3·8 of the whole. The record of the hourly positions, exclusive of those thus separated, was then rearranged and rewritten in *Lunar Tables*, according to the *Lunar hours* to which each position most nearly corresponded; and from these the mean variation in each lunar hour in each year was derived, as shown in the subsequent Tables, Nos. II., III., and IV.

The tabulation from the photograms and the subsequent calculations were executed at the Magnetic Office at Woolwich, under the superintendence of Mr. JOHN MAGRATH.

I have been thus particular in stating the processes which the photographic records have undergone, first, because that which forms the subject matter of the investigation, viz. the moon's action on the magnetism of the globe, is measurable only by very minute quantities, and requires consequently peculiar care and suitable arrangements for its satisfactory detection and determination; and secondly, because the results, now submitted to the Royal Society, present a variation which, small as it is in amount, is far too regular and too systematic to be ascribed to accidental causes, and affords a strong indication of the existence of a general law, the complete development of which has yet to be looked for from the extension of similar investigations in other localities. A great encouragement to the prosecution of the research is supplied by the remarkable correspondence of the phenomena of the lunar-diurnal variation at Kew, as now made known to us, with those at Hobarton, shown by the results of the observations at that Observatory between the years 1843 and 1848. The general aspect of the variation produced by the moon's influence at the two stations is the same, viz. a double progression in every twenty-four lunar hours, producing extreme deflections of the same character at opposite points of the moon's diurnal course; the turning-points of the variation taking place nearly at the same lunar hour at each of the two stations, and the amounts of the variation being approximately the same at both. The stations (Kew and Hobarton) being in opposite magnetic hemispheres, we might naturally expect what we actually find to be the case, that the lunar hours of the maxima of *Easterly* deflection in the one hemisphere are those of *Westerly* deflection in the other hemisphere, and *vice versâ*; and that the lunar hours of the maxima and minima of the north Dip and of the northern Total Force at Kew are the same as those of the maxima and minima of south Dip and of the southern

Total Force at Hobarton. The approximate accordance of the numerical values of the lunar influence at the two stations, and in each of the three elements, is also the more remarkable when we take into view the shortness of the time during which the investigation has as yet been prosecuted, and the minuteness of the quantities which are involved—measured as they are by a few seconds of arc in the Declination and Inclination, and by millionth parts of the terrestrial magnetic force. Such an accordance cannot be viewed otherwise than as a great encouragement to the continuance of the research where it is already in progress, and to its adoption elsewhere.

The conclusions in regard to the Declination are those which will perhaps be generally regarded as entitled to principal consideration, inasmuch as their derivation is much more direct than in the cases either of the Inclination or of the Total Force. To this it may be added that, in comparing the declination-phenomena at Kew and Hobarton, we have the advantage of a somewhat larger series of observations than is the case either in the Inclination or in the Total Force, as the hourly observations of the Declination at Hobarton in 1841 and 1842 are available for the purpose, in addition to those of the subsequent years 1843–1848; making together eight years of the Declination, whilst we have only six years of either the Horizontal or the Vertical Force. In all cases, however, and whether from Kew, Hobarton, or elsewhere, the numerical values which we may derive in regard to the lunar influence can only be regarded as approximations; and as indicating generally what we may expect will be accomplished by a further perseverance, rather than as preferring a claim to present or immediate *precision*. With this reservation we may view the facts regarding the moon's influence on the magnetic declination at Kew and Hobarton as placing beyond doubt the existence, at this particular epoch in the great cycle of the variations of the terrestrial magnetism, of a lunar-diurnal variation which has two equal or very nearly equal progressions, both in time and in amount; producing consequently two easterly and two westerly maxima of deflection in every lunar day, with four nodal epochs, occurring also at nearly equal intervals of lunar time, in which the direction of the magnet due to other causes is undisturbed by the moon's influence. The lunar hours of extreme deflection at Kew and Hobarton are 1, 7, 13, and 19; 1 and 13 being the westerly extremes at Kew and easterly at Hobarton; the nodal hours, or those in which the lunar influence is inoperative in producing deflection, are, as nearly as can be judged, strictly intermediate between the times of extreme deflection; viz., between 4 and 5, 10 and 11, 16 and 17, 22 and 23 hours. The amounts of the extreme deflections, measured by the mean of all the observations hitherto, are at Kew, westerly, $11''\cdot 1$ at 1 hour, $9''\cdot 4$ at 13 hours; easterly, $11''\cdot 6$ at 7 hours, $10''\cdot 8$ at 19 hours: at Hobarton, easterly, $8''\cdot 4$ at 1 hour, $9''\cdot 1$ at 13 hours; westerly, $7''\cdot 3$ at 7 hours, and $9''\cdot 1$ at 19 hours. The antagonistic terrestrial magnetic force by which the deflecting action of the moon on the horizontal magnet is opposed, is (approximately) 4·5 at Hobarton, and 3·8 at Kew, expressed in British units.

If we now extend this examination to other stations in the middle latitudes where

the same methods of investigation have been pursued, though with series of observations of shorter continuance, we find an approximation to the results at Kew and Hobarton far too close to be accidental. Everywhere there is evidence of a similar double progression in the lunar day with branches of nearly equal duration. The extreme deflections which we have noted as occurring at Kew and Hobarton at the lunar hours of 1 and 13 (easterly at Kew and westerly at Hobarton), are recorded as occurring at Toronto at 0^h and 12^h, at Philadelphia at 1^h and 13^h, and at Pekin at 23^h and 11^h, all being maxima of easterly deflection; and at the Cape of Good Hope (a *westerly* maximum, as the Cape is in the southern hemisphere) at 23^h and 11^h. In like manner the hours which characterize the opposite extremes at Kew and Toronto to those just noticed, viz., the westerly at Kew and easterly at Hobarton, which are at 7^h and 19^h, are recorded as occurring at Toronto at 6^h and 18^h, at Philadelphia at 7^h and 19^h, at Pekin at $5^h{\cdot}5$ and $17^h{\cdot}5$, and at the Cape of Good Hope at $5^h{\cdot}5$ and $17^h{\cdot}5$.

Some difference, in the time of the occurrence of a particular phase of the variation, as well as in its amount, we should be prepared to find in different localities, due to differences in their position on the surface of the magnetic sphere; but with this allowance there is a systematic consistency in the particulars which have been cited, which, even in this, the infancy of the inquiry, promises to conduct those who will pursue it to the recognition of one of those laws of general application which characterize the operation of great cosmical forces.

A corresponding accordance in the phenomena of the lunar influence on the Inclination and on the Total Force might easily be shown, even from the very brief record which we as yet possess from the very few stations at which the phenomena have been made the objects of investigation, carried on with suitable instruments and with suitable methods of reduction. The conclusions from them are indeed somewhat less precise than in the case of the Declination, because the conditions of the problem are necessarily more complex; but they have the same general character and bearing in all material respects; and enough has already been stated to establish the general fact of the existence and systematic action of the moon's magnetic influence at the surface of our globe, and to show that its phenomena are quite within the reach of properly directed research; and that they are assuredly well worthy of the attention of those who occupy themselves in the pursuits of inductive philosophy.

To establish on a satisfactory basis the existence of a difference in the amount of the lunar-diurnal variation at the times when the moon is nearest to or furthest from the earth, would probably require many more years of observation than have hitherto been given to the subject at Kew. But it may not be superfluous to state that in the Vertical Force, which is the only one of the elements in which the extreme deflections at the turning hours on the two days preceding and the two days subsequent to the epochs of perigee and apogee have hitherto been separately examined, the deflections are decidedly greater in their mean amount in perigee than in apogee; which is so far encouraging towards a continuance of the examination in future years.

Semiannual Inequality.—In the elaborate and very valuable discussion of the magnetic observations at Girard College, Philadelphia, 1840–1845, contained in the thirteenth volume of the 'Smithsonian Contributions to Knowledge' (1863), Dr. ALEXANDER DALLAS BACHE, For. Mem. R.S., announced the existence of a semiannual inequality in the lunar-diurnal variation of the Declination as shown in two particulars, (1) that the amplitudes of the deflections both to the east and to the west, and in both the 12-hourly divisions of the (lunar) diurnal variation, are less in the six months from October to March than in the six months from April to September; and (2) that the lunar hours at which the deflections pass through the zero are earlier by more than an hour in October to March than in April to September (Smithsonian Contributions, vol. xiii. part 3, pp. 11–13). In the case of the Horizontal Force, Dr. BACHE finds a similar semiannual inequality in the hours of maxima and minima, but in respect to their *amounts* he remarks that the range in April to September is but *slightly greater* than that in October to March, the difference being by no means so marked a feature as in the Declination (Smithsonian Contributions, vol. xiii. part 6, p. 72). The lunar-diurnal variation of the Vertical Force at Girard College does not appear to have been examined.

The above results were derived by a treatment of the observations conducted according to the same general principles, in regard to the separation of the larger disturbances, which had been previously introduced by myself in the discussion of the British Colonial magnetic observations.

Following Dr. BACHE'S example in this particular investigation, I directed Mr. MAGRATH, who is charged with the superintendence (under myself) of the reduction of the magnetic observations at the Woolwich Office, to separate the lunar-diurnal effects at Kew into two portions, one of which should contain the months from April to September inclusive, and the other the months from October to March inclusive, being the division of the year adopted by Dr. BACHE. The subjoined Table (No. V.) exhibits the *semiannual* as well as the annual means of the lunar-diurnal variation of the Declination at Kew taken from the photograms commencing January the 1st, 1858, and terminating December 31, 1864. The Table is divided into two portions solely for convenience in printing.

TABLE V.—Annual and Semiannual Means of the Lunar-diurnal Variation of the Declination at Kew.

Lunar Hours.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
Semiannual Means ... April to September..	−0′·23	−0′·25	−0′·19	−0′·06	+0′·01	+0′·08	+0′·20	+0′·29	+0′·17	+0′·07	+0′·04	−0′·12
Semiannual Means ... October to March ...	−0·03	−0·13	−0·18	−0·06	−0·15	−0·04	+0·04	+0·09	+0·15	+0·09	+0·02	+0·01
Annual Means	−0·13	−0·19	−0·18	−0·06	−0·07	+0·02	+0·12	+0·19	+0·16	+0·08	+0·03	−0·05

Lunar Hours.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
Semiannual Means ... April to September..	−0′·18	−0′·19	−0′·15	−0′·05	+0′·06	+0′·17	+0′·18	+0′·20	+0′·15	+0′·11	−0′·04	−0′·15
Semiannual Means ... October to March ...	−0·06	−0·12	−0·11	−0·07	0·00	+0·01	+0·09	+0·16	+0·17	+0·11	+0·11	+0·07
Annual Means	−0·12	−0·16	−0·13	−0·06	+0·03	+0·09	+0·14	+0·18	+0·16	+0·11	+0·03	−0·04

It is obvious on an inspection of this Table that the deflections of the Declination at Kew, both those that are easterly and those that are westerly, attain a greater amplitude in the months April to September than in the months October to March, and that the extremes appear to be reached at a somewhat *earlier* hour at Kew in the April to September than in the October to March portion of the year. The first of these indications is in accordance with the results at Philadelphia; the second is not so. With respect to the first, viz., the greater amplitudes in the months April to September, if we take the hours 22 to 3 and 10 to 15 as those of the − variation, and the hours 4 to 9 and 16 to 21 as those of the + variation for both half years, we have the sums (disregarding their half-yearly signs) of the semiannual monthly means for April to September 2′·50, and for October to March 1′·23. And if, retaining the hours 22 to 3, 4 to 9, 10 to 15, and 16 to 21 as the most suitable division in the April to September half year, we adopt the division of 23 to 4, 5 to 10, 11 to 16, and 17 to 22 as possibly preferable for the October to March half year, we have the sums (disregarding their signs) of the semiannual monthly means, 2′·50 in April to September and 1′·83 in October to March. In both arrangements the deflections are considerably greater in the April to September half year than in the October to March half year.

The Kew results appear therefore to be confirmatory of the Philadelphia results as to the greater amplitude of the lunar-diurnal deflections in April to September; but in regard to a slight priority in the hours of occurrence of the maxima and minima in either half year, the inference from the observations at Kew would be, as far as it goes, dissimilar to that deduced by Dr. BACHE from the observations at Philadelphia.

Such being the case, it appeared the more desirable to make a similar examination of the lunar-diurnal variation of the Declination at a station (Hobarton) in the opposite, *i. e.* in the southern hemisphere, from whence we have nearly eight years of hourly eye-observations, viz. from January 1, 1841 to September 30, 1848. Table VI. exhibits the semiannual and annual means of the lunar-diurnal variation of the Declination at Hobarton arranged as at Kew and Philadelphia.

TABLE VI.—Annual and Semiannual Means of the Lunar-diurnal Variation of the Declination at Hobarton.

Lunar Hours.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
Semiannual Means ... April to September ...	0′·00	−0′·03	+0′·06	+0′·03	+0′·07	−0′·01	−0′·09	−0′·02	−0′·01	+0′·03	0′·00	+0′·08
Semiannual Means ... October to March......	+0·34	+0·40	+0·30	+0·25	+0·11	−0·10	−0·21	−0·32	−0·30	−0·20	−0·06	+0·05
Annual Means	+0·17	+0·18	+0·18	+0·14	+0·09	−0·05	−0·15	−0·17	−0·15	−0·08	−0·03	+0·07

Lunar Hours.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
Semiannual Means ... April to September ...	+0′·07	+0′·12	+0′·13	+0′·12	+0′·12	+0′·03	−0′·02	−0′·09	−0′·14	−0′·16	−0′·06	−0′·08
Semiannual Means ... October to March......	+0·17	+0·36	+0·29	+0·14	+0·07	−0·11	−0·31	−0·38	−0·32	−0·19	−0·01	+0·18
Annual Means	+0·12	+0·24	+0·21	+0·13	+0·09	−0·04	−0·16	−0·24	−0·23	−0·18	−0·04	+0·05

At Hobarton the results appear to be quite as consistent and systematic as those at Kew or at Philadelphia, whilst in respect to the period of the year when the amplitudes of the deflections are greatest, they present the phenomena in the reversed order, October to March taking the position which at Kew and Philadelphia characterizes the April to September half year. If we take the hours 0 to 5, 12 to 17 as those of + deflections, and 6 to 11, 18 to 23 as those of − deflections for both the half years at Hobarton, we have the sums (disregarding their signs) of the semiannual monthly means for October to March $4'\cdot29$, and for April to September $1'\cdot27$; or if 23 to 4, 5 to 10, 11 to 16, 17 to 22 be taken, as possibly a preferable arrangement for the half year October to March (retaining as before 0 to 5, 6 to 11, 12 to 17, and 18 to 23 for the months April to September), we have the sum $5'\cdot05$ for October to March against $1'\cdot27$ for April to September. Under either arrangement the disparity is considerable, and appears decisive in favour of regarding October to March as the half year of greatest deflection in the lunar-diurnal variation at Hobarton. October to March is also the season of the earlier occurrence of the maxima and minima: in both the presumed half-yearly characteristics, therefore, the Declination at Hobarton, in the southern hemisphere, presents the opposite features to the Declination at Kew in the northern hemisphere.

I have added in Tables VII., VIII., IX. and X., at the close of this communication, the annual and semiannual means of the lunar-diurnal variation of the Inclination and of the Total Force at Kew and at Hobarton, although the number of years from which these have been derived can hardly be considered sufficient to afford any secure foundation for more than very general inferences in these two elements. For more assured evidence we must await the continuation of the Kew Observations for the northern hemisphere, and the magnetic investigations about to be commenced at Melbourne for the southern hemisphere.

In the meantime what is most worthy of our consideration is, that all the tables (in the separate half years as well as in the whole year, and in all elements and all localities) concur in the manifestation of that which is the great and distinctive characteristic of the lunar-diurnal variation, viz. a double fluctuation in the twenty-four lunar hours in equal or nearly equal divisions. It is this feature which must chiefly press itself on the attention of those who would address themselves to the solution of the somewhat difficult problem of the true theory of the moon's influence on the magnetism of the earth. May it not be possible that this peculiar feature may be connected with the duplex system of the terrestrial magnetism?

TABLE I.—Synopsis of the number of Hourly Positions tabulated from the Magnetic Photographs at Kew in the Years from 1858 to 1864 inclusive.

Magnetic elements.	Years.	Actual number of hours.	Actual number of recorded positions.	Interruption by other experimental inquiries.			Failures, and their causes.											Sums of recorded positions and failures.
				Examination of scale-coefficient.	Instrumental adjustments.	Presence of other magnets.	Lamp out.	Clock stopped.	Clock line broken.	Cylinder stopped.	Glass chimney smoked.	No zero-line.	No trace.	Curve off the paper.	Curve no beginning or end.	Omitted. *	Total failures from all causes.	
Declination.	1858.	8760	8618	......	......	12	16	4	......	......	......	......	110	......	......	......	142	8760
	1859.	8760	8701	3	......	......	......	12	......	......	......	......	44	......	......	......	59	8760
	1860.	8784	8720	2	......	......	......	20	......	......	......	......	40	......	......	2	64	8784
	1861.	8760	8692	8	......	......	......	16	......	......	......	......	20	......	24	......	68	8760
	1862.	8760	8693	4	......	......	......	8	......	22	......	......	29	......	......	4	67	8760
	1863.	8760	8743	6	......	......	......	4	......	......	......	......	6	1	......	......	17	8760
	1864.	8784	8744	5	1	3	10	2	8	......	......	......	7	4	......	......	40	8784
	Total ...	61368	60911	28	1	15	26	66	8	22	......	......	256	5	24	6	457	61368
Horizontal Force.	1858.	8760	8632	......	7	......	33	5	......	......	......	......	74	......	......	9	128	8760
	1859.	8760	8662	3	......	......	33	5	......	......	......	18	37	......	......	2	98	8760
	1860.	8784	8672	......	......	......	......	18	......	......	10	......	84	......	......	......	112	8784
	1861.	8760	8716	3	1	......	......	16	......	......	......	......	24	......	......	......	44	8760
	1862.	8760	8693	2	......	......	......	8	......	......	......	......	57	......	......	......	67	8760
	1863.	8760	8689	4	......	3	......	4	......	......	......	48	11	......	......	1	71	8760
	1864.	8784	8738	2	......	3	10	2	8	......	......	......	19	......	......	2	46	8784
	Total ...	61368	60802	14	8	6	76	58	8	......	10	66	306	......	......	14	566	61368
Vertical Force.	1859.	8760	8650	......	25	2	4	12	......	......	......	5	61	......	......	1	110	8760
	1860.	8784	8618	5	......	......	21	18	1	......	......	......	118	1	......	2	166	8784
	1861.	8760	8704	1	......	......	......	15	......	......	......	24	16	......	......	......	56	8760
	1862.	8760	8725	2	1	......	......	6	2	......	......	......	20	1	......	3	35	8760
	1863.	8760	8690	2	......	......	......	3	......	......	......	48	13	1	......	3	70	8760
	1864.	8784	8747	4	......	......	10	2	8	......	......	......	13	......	......	......	37	8784
	Total ...	52608	52134	14	26	2	35	56	11	......	......	77	241	3	......	9	474	52608
General Total...		175344	173847	56	35	23	137	180	27	22	10	143	803	8	24	29	1497	175344

* The term "omitted" applies to cases wherein the photograms were marked by a red line drawn over a portion of the curve with the direction "omit." These markings were made by Mr. CHARLES CHAMBERS (now in India), under whose superintendence the photograms were prepared. In all the cases so marked there were slight irregularities noticeable in the traces, due possibly to the presence of visitors in the magnetometer room, who may have had keys or knives in their pockets. But whether from these or other causes the hourly positions thus omitted amount only to 29 in number in the three elements in the seven years.

TABLE II.—Declination. Lunar-diurnal Variation in Seconds of Arc.

Lunar hours.	Years ending December 31. 1858.	1859.	1860.	1861.	1862.	1863.	1864.	Means.	Lunar hours.
	″	″	″	″	″	″	″	″	
0	W. 6·0	E. 0·6	W. 12·6	W. 5·4	W. 7·8	W. 9·0	W. 14·4	W. 7·8	0
1	W. 14·4	W. 7·2	W. 12·6	W. 6·0	W. 6·6	W. 17·4	W. 13·2	W. 11·1	1
2	W. 10·8	W. 9·6	W. 5·4	W. 7·2	W. 9·0	W. 12·0	W. 21·0	W. 10·7	2
3	W. 7·8	W. 4·2	W. 3·0	E. 2·4	E. 2·4	W. 6·6	W. 7·8	W. 3·5	3
4	W. 3·0	W. 4·2	W. 2·4	E. 4·2	E. 2·4	W. 6·6	W. 19·8	W. 4·2	4
5	E. 5·4	W. 6·6	E. 5·4	E. 6·6	E. 9·0	W. 4·2	W. 6·6	E. 1·3	5
6	E. 12·0	E. 1·2	E. 3·0	E. 14·4	E. 14·4	W. 2·4	E. 7·8	E. 7·2	6
7	E. 9·0	E. 4·2	E. 9·6	E. 16·2	E. 17·4	E. 15·6	E. 9·0	E. 11·6	7
8	E. 9·6	E. 8·4	E. 7·8	E. 6·6	E. 14·4	E. 15·6	E. 5·4	E. 9·7	8
9	E. 7·2	E. 6·6	W. 0·9	W. 1·2	E. 12·0	E. 7·8	E. 2·4	E. 4·8	9
10	E. 3·0	E. 7·2	W. 1·8	W. 6·6	W. 2·4	E. 7·8	E. 5·4	E. 1·8	10
11	W. 3·6	W. 1·2	W. 4·2	W. 10·8	W. 7·8	E. 6·6	0·0	W. 3·0	11
12	W. 4·8	W. 9·0	W. 18·0	W. 8·4	W. 7·8	0·0	W. 4·2	W. 7·5	12
13	W. 3·0	W. 13·2	W. 15·0	W. 13·2	W. 12·0	W. 5·4	W. 4·2	W. 9·4	13
14	W. 3·0	W. 8·4	W. 9·6	W. 10·8	W. 15·6	W. 10·8	E. 1·2	W. 8·1	14
15	W. 7·2	W. 3·6	E. 4·2	W. 8·4	W. 12·0	W. 2·4	E. 5·4	W. 3·4	15
16	E. 3·0	E. 3·6	E. 7·8	W. 6·6	W. 10·8	0·0	E. 14·4	E. 1·6	16
17	E. 7·8	E. 9·6	E. 13·8	W. 2·4	W. 4·2	E. 1·2	E. 12·0	E. 5·4	17
18	E. 7·8	E. 14·4	E. 17·4	E. 3·0	0·0	E. 7·8	E. 5·4	E. 8·0	18
19	E. 4·8	E. 18·0	E. 15·0	E. 9·0	E. 2·4	E. 12·0	E. 14·4	E. 10·8	19
20	E. 3·0	E. 12·6	E. 6·0	E. 10·2	E. 12·0	E. 14·4	E. 9·0	E. 9·6	20
21	W. 2·4	E. 18·6	E. 2·4	E. 10·8	E. 7·8	E. 2·4	E. 7·8	E. 6·8	21
22	W. 7·8	E. 9·6	W. 3·0	E. 7·8	E. 5·4	E. 1·2	0·0	E. 1·9	22
23	W. 6·0	E. 5·4	W. 3·6	E. 0·6	W. 4·2	W. 1·2	W. 7·8	W. 2·4	23

TABLE III.—Horizontal Force. Lunar-diurnal Variation in parts of the Force at the Station.

Lunar hours.	Years ending December 31. 1858.	1859.	1860.	1861.	1862.	1863.	1864.	Means of the seven years.	Lunar hours.
0	+·000052	+·000039	+·000091	+·000033	+·000038	+·000087	+·000017	+·000051	0
1	+·000045	+·000080	+·000138	+·000067	+·000049	+·000098	+·000054	+·000076	1
2	+·000037	+·000075	+·000121	+·000080	+·000071	+·000085	+·000087	+·000079	2
3	+·000013	+·000103	+·000131	+·000055	+·000054	+·000040	+·000055	+·000064	3
4	+·000002	+·000091	+·000124	+·000022	+·000071	+·000026	+·000040	+·000054	4
5	—·000020	+·000076	+·000122	+·000029	+·000028	+·000028	+·000035	+·000043	5
6	—·000011	+·000020	+·000085	—·000023	—·000028	+·000056	—·000031	+·000010	6
7	—·000003	+·000010	+·000078	—·000061	—·000044	+·000001	—·000036	—·000008	7
8	—·000024	+·000018	+·000041	—·000063	+·000014	—·000009	—·000006	—·000004	8
9	—·000009	—·000023	+·000087	—·000118	—·000029	+·000024	—·000089	—·000022	9
10	—·000021	—·000032	+·000076	—·000060	+·000018	—·000008	—·000013	—·000006	10
11	—·000001	—·000031	+·000066	—·000047	+·000018	+·000060	+·000036	+·000014	11
12	+·000046	+·000015	+·000056	—·000024	+·000040	+·000083	+·000067	+·000040	12
13	+·000031	+·000025	+·000112	+·000022	+·000097	+·000073	+·000062	+·000060	13
14	—·000014	+·000050	+·000088	+·000013	+·000094	+·000123	+·000069	+·000060	14
15	+·000025	+·000033	+·000089	+·000032	+·000056	+·000079	+·000059	+·000053	15
16	+·000021	+·000054	+·000071	+·000049	+·000081	+·000058	+·000014	+·000050	16
17	+·000017	+·000034	+·000046	+·000042	+·000051	+·000017	—·000025	+·000026	17
18	+·000003	—·000033	—·000011	+·000027	·000000	+·000030	+·000029	+·000006	18
19	+·000018	·000000	+·000001	—·000025	—·000026	—·000019	+·000003	—·000007	19
20	—·000002	—·000034	+·000002	+·000013	—·000006	+·000011	—·000036	—·000007	20
21	—·000001	—·000010	—·000020	+·000043	—·000010	+·000017	—·000015	+·000001	21
22	—·000028	—·000021	+·000040	+·000012	+·000011	—·000010	+·000005	+·000001	22
23	+·000053	+·000027	+·000036	+·000010	+·000074	+·000042	+·000001	+·000035	23

The mean Horizontal Force at Kew is approximately 3·8 in British units.

TABLE IV.—Vertical Force. Lunar-diurnal Variation in parts of the Force at the Station.

Lunar hours.	Years ending December 31.						Means of the six years.	Lunar hours.
	1859.	1860.	1861.	1862.	1863.	1864.		
0	−·000019	−·000003	·000000	+·000017	−·000003	−·000025	−·000005	0
1	−·000008	+·000003	+·000001	+·000028	+·000011	−·000009	+·000004	1
2	−·000007	+·000008	+·000002	+·000030	+·000018	+·000003	+·000009	2
3	−·000006	+·000018	+·000017	+·000021	+·000015	−·000003	+·000010	3
4	−·000004	+·000008	+·000007	+·000020	+·000016	+·000006	+·000009	4
5	−·000012	·000000	−·000002	+·000016	+·000010	+·000005	+·000003	5
6	−·000013	+·000010	−·000008	+·000005	−·000001	−·000006	−·000002	6
7	−·000015	+·000001	−·000010	+·000004	−·000003	·000000	−·000004	7
8	−·000009	−·000006	−·000007	−·000001	−·000011	−·000006	−·000007	8
9	−·000017	−·000019	−·000018	−·000003	−·000012	+·000004	−·000011	9
10	−·000014	−·000004	−·000013	−·000004	−·000008	+·000006	−·000006	10
11	−·000004	−·000008	+·000008	+·000004	−·000005	+·000008	·000000	11
12	−·000005	−·000004	−·000011	+·000007	−·000005	+·000018	·000000	12
13	−·000005	−·000001	·000000	+·000004	−·000001	+·000012	+·000001	13
14	+·000001	+·000008	+·000002	+·000020	−·000004	+·000013	+·000007	14
15	+·000004	+·000020	+·000005	+·000021	·000000	+·000015	+·000011	15
16	+·000002	+·000003	·000000	+·000020	·000000	+·000014	+·000006	16
17	−·000001	·000000	+·000008	+·000021	−·000014	+·000024	+·000006	17
18	−·000006	−·000002	·000000	+·000011	−·000022	+·000007	−·000002	18
19	−·000018	−·000016	−·000002	+·000012	−·000033	+·000004	−·000009	19
20	−·000031	−·000015	−·000001	+·000012	−·000020	−·000006	−·000010	20
21	−·000034	−·000016	−·000013	−·000004	−·000033	−·000026	−·000021	21
22	−·000026	−·000018	−·000006	+·000004	−·000018	−·000023	−·000014	22
23	−·000021	−·000013	−·000007	+·000007	−·000012	−·000021	−·000011	23

The mean Vertical Force at Kew is approximately 9·5 in British units.

TABLE VII.—Annual and Semiannual Means of the Lunar-diurnal Variation of the Inclination at Kew.

Lunar Hours.		0^h.	1^h.	2^h.	3^h.	4^h.	5^h.	6^h.	7^h.	8^h.	9^h.	10^h.	11^h.
Semiannual Means ...	April to September ...	−0′·09	−0′·10	−0′·09	−0′·07	−0′·07	−0′·04	+0′·01	+0′·02	+0′·03	+0′·02	0′·00	−0′·01
	October to March......	−0·04	−0·08	−0·07	−0·04	−0·03	−0·04	−0·03	0·00	−0·03	0·00	0·00	−0·02
Annual Means		−0·07	−0·09	−0·08	−0·06	−0·05	−0·04	−0·01	+0·01	0·00	+0·01	0·00	−0·02

Lunar Hours.		12^h.	13^h.	14^h.	15^h.	16^h.	17^h.	18^h.	19^h.	20^h.	21^h.	22^h.	23^h.
Semiannual Means ...	April to September ...	−0′·06	−0′·11	−0′·08	−0′·09	−0′·07	−0′·01	+0′·02	+0′·01	+0′·01	−0′·03	−0′·01	−0′·06
	October to March......	−0·03	−0·03	−0·04	−0·01	−0·03	−0·04	−0·03	−0·02	0·00	−0·01	−0·02	−0·05
Annual Means		−0·05	−0·07	−0·06	−0·05	−0·05	−0·02	0·00	0·00	0·00	−0·02	−0·02	−0·05

Table VIII.—Annual and Semiannual Means of the Lunar-diurnal Variation of the Total Force at Kew, in parts of the Total Force at the Station.

Lunar Hours.		0^{h}.	1^{h}.	2^{h}.	3^{h}.	4^{h}.	5^{h}.	6^{h}.	7^{h}.	8^{h}.	9^{h}.	10^{h}.	11^{h}.
		·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00
Semiannual Means ...	April to September ...	+0006	+0020	+0026	+0027	+0020	+0018	+0004	+0003	−0000	−0005	−0003	+0006
	October to March	0000	+0012	+0013	+0010	+0011	0000	−0004	−0010	−0010	−0018	−0008	−0003
Annual Means		+0003	+0016	+0019	+0018	+0015	+0009	0000	−0004	−0005	−0012	−0005	+0002
Lunar Hours.		12^{h}.	13^{h}.	14^{h}.	15^{h}.	16^{h}.	17^{h}.	18^{h}.	19^{h}.	20^{h}.	21^{h}.	22^{h}.	23^{h}.
		·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00
Semiannual Means ...	April to September ...	+0015	+0021	+0022	+0028	+0027	+0016	+0001	−0001	−0006	−0016	−0011	−0001
	October to March	−0001	−0001	+0004	+0004	0000	+0002	0000	−0013	−0013	−0019	−0011	−0007
Annual Means		+0007	+0010	+0013	+0016	+0013	+0009	0000	−0007	−0010	−0018	−0011	−0004

Table IX.—Annual and Semiannual Means of the Lunar-diurnal Variation of the Inclination at Hobarton.

Lunar Hours.		0^{h}.	1^{h}.	2^{h}.	3^{h}.	4^{h}.	5^{h}.	6^{h}.	7^{h}.	8^{h}.	9^{h}.	10^{h}.	11^{h}.
Semiannual Means ...	April to September..	+0′·04	+0′·01	−0′·01	−0′·01	−0′·03	−0′·01	0′·00	0′·00	+0′·02	+0′·01	−0′·02	0′·00
	October to March ...	+0·01	−0·02	−0·04	−0·04	−0·05	−0·01	−0·04	−0·03	+0·02	+0·02	+0·03	+0·03
Annual Means		+0·02	0·00	−0·02	−0·03	−0·04	−0·01	−0·02	−0·01	+0·02	+0·01	0·00	+0·01
Lunar Hours.		12^{h}.	13^{h}.	14^{h}.	15^{h}.	16^{h}.	17^{h}.	18^{h}.	19^{h}.	20^{h}.	21^{h}.	22^{h}.	23^{h}.
Semiannual Means ...	April to September..	−0′·02	−0′·01	0′·00	−0′·02	−0′·03	0′·00	−0′·01	−0′·01	−0′·01	+0′·01	+0′·03	+0′·06
	October to March...	+0·02	−0·01	−0·04	−0·03	−0·04	−0·03	−0·01	+0·02	+0·03	+0·06	+0·05	+0·02
Annual Means		0·00	−0·01	−0·02	−0·02	−0·04	−0·02	−0·01	0·00	+0·01	+0·03	+0·04	+0·04

Table X.—Annual and Semiannual Means of the Lunar-diurnal Variation of the Total Force at Hobarton, in parts of the Total Force at the Station.

Lunar Hours.		0^{h}.	1^{h}.	2^{h}.	3^{h}.	4^{h}.	5^{h}.	6^{h}.	7^{h}.	8^{h}.	9^{h}.	10^{h}.	11^{h}.
		·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00
Semiannual Means ...	April to September..	+0002	−0005	−0007	−0011	−0006	−0001	+0003	+0005	+0004	+0006	−0003	−0002
	October to March...	+0005	+0005	−0002	−0001	0000	+0001	−0001	−0008	+0003	−0008	−0005	+0005
Annual Means		+0003	0000	−0004	−0006	−0003	0000	+0001	−0001	+0003	−0001	−0004	+0001
Lunar Hours.		12^{h}.	13^{h}.	14^{h}.	15^{h}.	16^{h}.	17^{h}.	18^{h}.	19^{h}.	20^{h}.	21^{h}.	22^{h}.	23^{h}.
		·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00
Semiannual Means ...	April to September..	−0001	−0006	−0003	−0002	+0001	+0006	+0007	+0011	+0009	+0007	+0003	+0002
	October to March...	0000	−0003	−0001	+0002	−0005	−0002	0000	+0005	+0003	+0008	+0007	+0007
Annual Means		0000	−0004	−0002	0000	−0002	+0002	+0004	+0008	+0006	+0007	+0005	+0004